

Organization of the Trigger Studies Group

1 Introduction and Charge of group

The Trigger Studies group (TSG) works on providing triggers tailored for the physics priorities as set by the Physics Coordination. The group collaboratively develops sets of triggers that

- are designed for different luminosity, beam and running conditions.
- have well-defined methods for determining efficiency, purity, and performance evaluation/monitoring.
- produce the data sets needed for physics, trigger studies and other special requirements.
- produce the data sets needed for detector calibration, alignment and monitoring, as specified by the DPGs.

The trigger sets proposed by the TSG are submitted for approval to the Trigger Executive Board (TEB). TSG and TEB are the constituents of the Trigger Coordination Level-1 CMS Task.

2 Definition and organization of TSG tasks

The work to be carried out by the TSG is divided into four main tasks or sub-groups: HLT code integration, Trigger performance, Trigger Menu integration and Trigger Menu development. Each of these groups is organized by two conveners. We outline below the corresponding responsibilities and “charges”¹.

2.1 HLT code integration

Responsibility: Incorporate (and modify as needed) code for physics object reconstruction from POGs/PAGs/DPGs and implement as HLT algorithms.

The group ensures that:

¹In many cases the work to be done cuts across more than one of the four groups. The description of these tasks should therefore not be considered as autonomous “territories”, but instead as common work of collaborating parts carrying out the charge of the TSG.

- each HLT algorithm satisfies the modular structure of the framework (L1 preconditions, data-unpacking, producers, filters, book-keeping) and that it can run in the trigger menu with or without other HLT paths.
- the information stored by HLT for tagging and book-keeping purposes will comply with the (online, FEVT, AOD) size and performance requirements and will gradually evolve according to feedback received by the Offline, Physics and Trigger groups.
- the resulting data streams are usable by the POGs/PAGs.

The group works closely with the Offline framework coordination to ensure that the framework provides the tools required for optimal HLT performance and that the HLT code complies with the CMS software architecture. The group includes contacts from all PO and PA groups who work on the HLT path implementation.

2.2 Trigger performance

Responsibility: Evaluate the performance of the individual trigger algorithms (CPU/memory performance, background rejection and physics efficiency of signal events).

The performance of a trigger is evaluated at different stages:

- Online DQM: While we are running (with low statistics and non-final calibration and alignment) to decide if we need to take immediate action to fix a problem. Anything from incorrect trigger configuration to dirty beam conditions, hot channels or unstable trigger behavior.
- Offline DQM: After the run (with higher statistics and almost final calibration and alignment) to decide if the trigger has had the expected behavior and if the run as taken is good for physics.
- Algorithm Performance: By using MC (before data-taking) and (after data-taking starts) DATA to determine if the trigger meets the physics and CPU/memory performance requirements, and decide if modifications are needed.

The group “validates” the trigger paths that are part of a new software release or Trigger Menu, by ensuring that observed changes in performance are well understood and intended. Validation tests with quantitative information should be routinely run for every trigger path, new software (pre)release and proposed Trigger Menu². Since triggers are typically used by many physics groups, it is expected that any given trigger must be “blessed” by all the interested parties.

The group includes contacts from all PO and PA groups that are responsible for ensuring the usefulness of their triggers (“physics yield”) at a reasonable cost (bandwidth and CPU/memory price). The provision of the data-sets and online and offline event streams

²Details can be found in Sec. 3.2.1

needed for trigger DQM and performance studies is the responsibility of the trigger performance group.

The group extensively uses the L1 trigger emulators for studies of the L1 Trigger Performance. The validation of the L1 Trigger Emulators is the responsibility of the L1 Trigger Project and coordination is provided by the L1 Emulator Conveners. The Online DQM, Offline DQM and Algorithm Performance sub-group conveners either themselves or through link-persons in the L1 Trigger Project, coordinate with the L1 Trigger Project in evaluation of the validation of trigger data formats (unpackers, *etc.*), validation of L1 synch and validation of L1 algorithms, using the trigger and detector data. These individuals and the rest of the TSG Trigger Performance Group form the Trigger “Detector Performance Group” (DPG).

2.3 Trigger Menu integration

Responsibility: Produce and validate an operationally functional suite of triggers.

This group integrates and validates the full set of trigger paths that comprise the Trigger Menu. It evaluates the (expected) rates, CPU-performance and memory footprint of the menu by taking into account trigger coincidences and common processing modules for a given L1 bandwidth allocation. It ensures the stability of the system by running on very large (MC background or previously-taken data) samples and a set of (cumulatively collected) pathological events known to have caused problems in previous trigger versions. It interacts with the EvF group to ensure the smooth deployment of the HLT algorithms in the online environment.

Other tasks include:

- Data unpacking: Ensure data-integrity and unpacking efficiency so we provide exactly what we need for the trigger algorithms in the most economical way.
- Menu optimization and testing: Work closely with the POG/PAG contacts to ensure the fastest possible rejection for any given trigger menu.
- Calibration and alignment: Implement the requirements from the DPG groups for the needed calibration and alignment triggers and evaluate the resources of bandwidth, processing and storage needed.

For the calibration and alignment task, contacts from each DPG group are required.

2.4 Trigger Menu development

Responsibility: Develop, study and propose new trigger menus for future use.

Unlike the Trigger Menu integration team that works on the “current” Trigger Menu (for the latest software release or the next Physics run), this groups is planning the next iteration of trigger menus, given feedback from ongoing runs or adjustments needed for different beam/luminosity scenarios.

This is where the trigger studies with MC and eventually data samples will be centered. The work includes:

- Menu compilation and evaluation: the sets of PO and PA triggers that will form the new trigger menus, adjusted for different luminosities or improved performance. The PAG/POG contacts are responsible for improving the existing triggers and/or the development of new ones.
- Performance Metrics: Every new trigger proposed (and new trigger menus) must have a complete suite of validation tests accompanying them that demonstrate how the trigger will be monitored. Eventually these tests will become part of the Trigger Performance effort.
- Rates and prescales: The rates and, if needed, groups of prescales determined that provide for physics signals and the samples needed to measure trigger efficiencies.

The group ensures the provision of the data-sets and event streams needed for trigger development studies.

3 Collaboration with other CMS groups

3.1 Physics

3.1.1 Coordination

The Trigger Coordinator and the Deputy attend the Physics Coordination meetings for the specific purpose of providing input on trigger issues to Physics Coordination and to receive guidance on physics issues. The Physics Groups Trigger liaison attends the TSG meetings.

3.2 Offline

3.2.1 Software release validation

The HLT code integration, Trigger performance and Trigger Menu integration groups are responsible for testing and validating the L1 and HLT code in a software release cycle, starting from the corresponding pre-releases. In particular

- The HLT code integration group (in collaboration with the L1 emulator coordination) catches early errors requiring one or very few MC events:
 - checks for inconsistencies or illegal-dependencies between HLT paths
 - makes sure the Trigger Menu can run “out of the box” for a given (pre)release starting from RAW information (including L1 objects)
 - investigates errors and problems (e.g. unnecessary printouts)

- The Trigger Menu Integration group looks at the global performance of the trigger by using larger statistics:
 - investigates errors that have not been uncovered and resolved by running on smaller statistics in the previous step
 - evaluates trigger rates and the average CPU-processing time per L1-accepted event
 - helps with problems identified at or associated with the online environment
- The Trigger performance group uses dedicated samples and reports
 - signal efficiencies (for a few benchmark channels from every PAG) by running on the appropriate RelVal signal samples
 - the average CPU-processing time per path and background rejection for each L1 bit and HLT path. Higher statistics studies are done at the end of release cycles.³

3.2.2 Coordination

One of the two HLT code integration Conveners attends the Offline Framework and Software Development Tools meetings. One of the two Trigger Menu Integration Conveners attends the Offline Release and Data Operation Planning Meetings. One of the two Trigger Performance and the two Trigger Menu development Conveners attends the Offline Reconstruction meetings. These individuals provide information on the status and plans of TSG activities to these groups and coordinate trigger planning with the plans agreed to during these meetings. In addition, they report on issues and action items from these meetings relevant to trigger coordination at every TSG meeting.

3.3 TriDAS

3.3.1 Coordination

The L1 Emulator Conveners attend the TSG meetings. The Event Filter Trigger liaison attends the TSG meetings. The Event Filter liaison from the Trigger Menu integration group attends the Event Filter meetings. Representative members of the Trigger Performance Group attend the L1 Trigger Meetings.

³For those studies requiring large MC or data background samples, if these samples are not available due to such issues as backwards compatibility, the background testing should be performed at the end of the release cycle only, with a new MC production or data taken in a test run.